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The lesser apple leaf-folder

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Iowa State College

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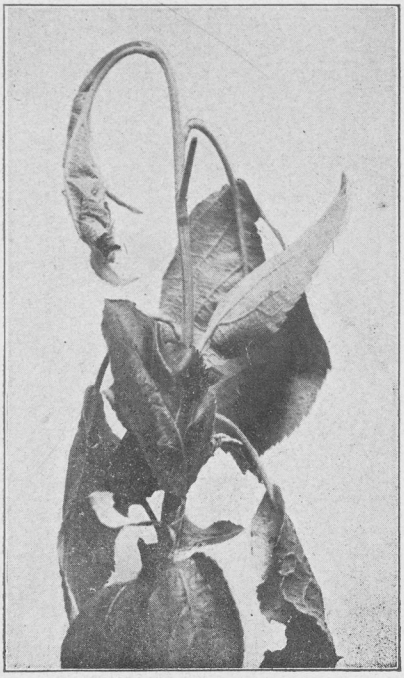
ENTOMOLOGICAL SECTION



THE LESSER APPLE LEAF-FOLDER

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SUMMARY.

The lesser apple leaf-folder is a small green "worm" which folds the leaves of apple and plum stock in nurseries and young orchards. The leaves are folded over flat, the lower surface of the leaf outside and the fold usually along the midrib. The "worm" itself is green, about half an inch long, and has a pale yellow head.

The leaf-folders appear three times during the season: First, as soon as the leaves are out on the trees; second, about the middle of June; third, early in August. The folders remain on the trees from four to six weeks before they become mature.

To be effective, spraying must be done when the leaf-folders are very young, or when they are still in the egg stage. The proper times to spray, as determined by the experimental work in this state, are as follows: First, as soon as the leaves appear; second, the first week in June; third, the first week in August. These dates are for an average season.

The home-made arsenate of lead gave excellent results in spraying for the leaf-folders, applied when the folders were still in the egg stage. The 1½ strength is advised and is made as follows:

Arsenate of soda	6 ounces
Acetate of lead	18 ounces
Water	50 gallons

Dissolve the two chemicals in separate vessels, each in about two quarts of water. The sugar of lead may need to be slightly warmed to make it dissolve. When ready to use pour the two solutions separately into fifty gallons of water, thus forming the arsenate of lead.

If a prepared arsenate of lead is used, 2 or 3 pounds of the paste should be taken to 50 gallons of water. Paris green may be used, although the arsenate of lead is considered better. One-third of a pound to 50 gallons of water should be sufficient, adding about a pound of lime to prevent burning of the leaves.

THE LESSER APPLE LEAF-FOLDER
Peronea minuta Rob.

BY R. L. WEBSTER

INTRODUCTION.

RECENT INJURY TO NURSERY STOCK IN IOWA.

During the past two years several Iowa nurseries which grow large quantities of apple stock have been seriously troubled by a small green caterpillar which folds or ties up the young tender leaves of the growing trees, stunting the growth of the stock. This small caterpillar is known as the "lesser apple leaf-folder," on account of its habit of folding apple leaves. The scientific name of this pest is *Peronea minuta.*

Two of the large nurseries of this state located at Shenandoah, have had serious trouble with this insect for the last two years. At Shenandoah the leaf-folders became exceptionally numerous in the fall of 1907, and continued so during the spring and summer of 1908. Another nursery at Des Moines, which grows considerable apple stock, has also been troubled with this same leaf-folder during the past summer.

APPEARANCE OF INJURY.

Apple stock of all ages is attacked by the leaf-folder, the young grafts as well as the 3-year-old trees. The new leaves on the terminal branches of the trees are favorite positions for the leaf-folder to work. The "worm," or larva, folds a single leaf, or ties several small leaves together, and remains inside this hiding place, where it feeds undisturbed. As a result, infested trees present a tied-up and scraggly appearance where the leaf-folders become very numerous. The leaves within which the folder works turn brown as a result of the feeding, and a badly infested block of apple stock may have the appearance of having been swept by fire.

SPECIFIC INDICATIONS OF THE PRESENCE OF LEAF-FOLDER.

As its name indicates, this insect folds the leaves of the apple. A small tender leaf may be folded longitudinally along the midrib, with the upper surface drawn over, and the whole leaf presenting a flat appearance. Where a young larva folds a comparatively large leaf only a part of the margin is folded over the upper surface and fastened down

flat to the leaf. Frequently several young larvae will tie up the tender unfolding leaves of the growing tips and work inside the protection thus formed. In such a place the larvae often bore through the tender leaves, riddling them with small holes. Again, when two large leaves are contiguous the larva may sew them flat together, and live in the hiding place formed between the two.

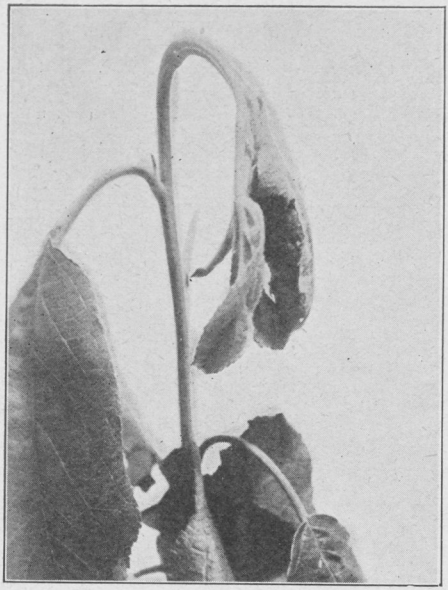
In June and again in August the orange-colored moth of the leaf-folder may be seen flying about in the rows of nursery stock. The time of the season at which these moths are seen flying in any numbers is an important one, since this marks the proper time to spray for the second and third broods of the leaf-folders. If the third brood is very numerous the slate-colored form may be seen among the leaves in the nursery row in October.

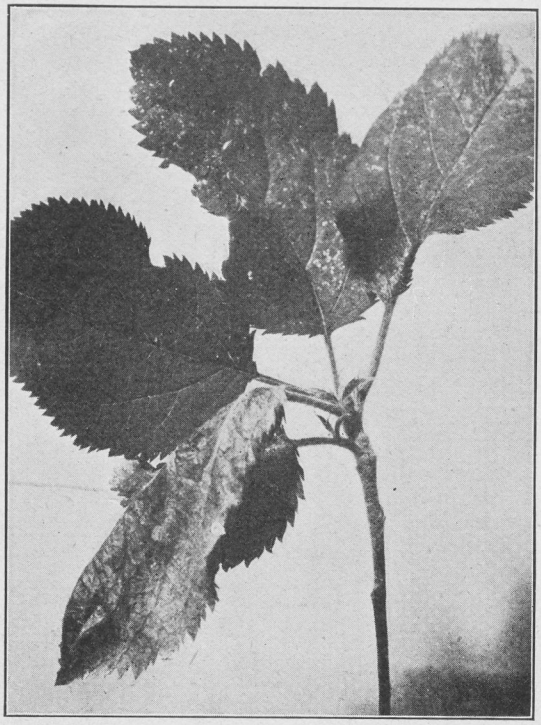
THE INSECT'S APPEARANCE.

The leaf-folder itself is a greenish yellow "worm," about half an inch long when it is full grown. It is slightly hairy, but these hairs, or setae, are hardly noticeable. When the leaf-folder has reached its full growth it changes to the pupa, or resting stage, during which it does not feed. The pupa is about three-tenths of an inch long, brown, with a small knob in front of the head by which it may be easily distinguished from the pupae of other common leaf-rollers. Those pupae found in the fall were somewhat larger than those found in the spring and summer. After a week or ten days the moth, or adult insect, emerges from the pupa. These moths deposit their eggs, from which hatch a new brood of young leaf-folders.

There are two different forms of the moths, an orange-colored form, which appears in the late spring and in the summer; and a slate-colored form, which appears in the fall. Thus for the first and second broods the orange moth appears, and for the third brood, the slate moth, both being the same species of insect. Such a phenomenon is known as dimorphism, that is, having two forms. Both the orange and slate forms measure about a third of an inch long, and a little more than half an inch across the expanded wings. Slate moths reared in the insectary this fall averaged somewhat larger than the orange moths of the other two broods.

The distinguishing characters of the larva are the yellowish head and cervical shield, just back of the head. Other common leaf-rollers which are found on the apple usually have a brown or a black head. This particular larva is rather small, something over half an inch long when full grown, while the other common apple leaf rollers measure nearly an inch long when





Figs. 1 and 2. Work of Apple Leaf-Folder. Reduced.

Fig. 3. Folder on Leaf. Slightly Reduced.

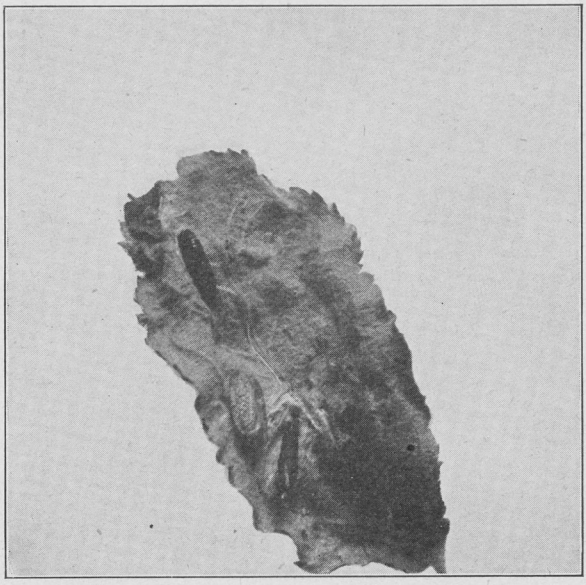


Fig. 4. Pupae and Moth on Leaf. Natural Size.

mature. The flat folded leaf will usually distinguish the work of this larva from that of the other leaf rollers, which roll the leaf in a cylindrical fashion, rather than folding it.

PREVENTIVE MEASURES.

PICKING LEAVES.

Where there is only a small area infested with the lesser apple leaf-folder much benefit may be obtained by picking or pinching the infested leaves. This sort of work may easily be done by boys going down the rows and picking the folded leaves as they go. It is not necessarily a very expensive undertaking, and when it is well done, is certainly worth while. It has been estimated that the cost of picking would not exceed $1 per acre. This estimate, however, was made some years ago, and the cost at the present time would probably exceed that sum.

In the "snagging" process on 3-year-old apple trees in the spring many of the larvae are removed from the trees on the short "snags." About the time this pruning is going on a considerable proportion of the larvae are feeding on leaves on the lower part of the tree, that is, on the "snags." The leaves from these "snags" might be gathered up and burned, in this way reducing to some extent the number of leaf-folders on the trees. No doubt a thorough cultivation in the nursery rows immediately after this pruning would bury or crush many of the folders within the leaves.

LANTERN TRAPS.

Prof. J. M. Stedman of the Missouri station has made some experiments in trapping the moths by means of lantern traps. These traps are made by placing a lantern in a shallow pan containing some kerosene. The moths are attracted to the light, fall into the kerosene, and are killed. Lantern traps, however, attract numerous other insects as well as the moths of the leaf folder, and many of these are likely to be valuable friends of the fruit grower and farmer. Under such conditions the use of the lantern trap would not be profitable in the long run. The traps might be used to some extent, but for practical methods on any very large scale one must depend mainly on spraying to control this pest.

SPRAYING EXPERIMENTS ON NURSERY STOCK.

A series of spraying experiments was planned in the spring of 1908 in order to determine the best means of fighting this leaf-folder by the use of an arsenical spray. Practically all the

spraying was done with the home-made arsenate of lead, applied in three different strengths. Paris green was also used to a limited extent.

The formula for the single strength of this home-made product, which is used as the basis for the other strengths, is as follows:

Arsenate of soda	4 ounces
Acetate of lead	12 ounces
Water	50 gallons

Other formulas frequently read 11 ounces of the acetate of lead in place of 12 ounces. By using 12 ounces the ratio of one to three is maintained between the two materials, thus making the formula more readily handled. The other strengths used were the 1½ and the double strength.

For the sake of convenience the formulas are abbreviated to the terms 4-12-50, 6-18-50 and 8-24-50 for the single, 1½ and double strengths respectively. These abbreviations will be used in the succeeding tables.

In preparing this home-made product the two ingredients, arsenate of soda and acetate of lead (sugar of lead), are first dissolved in a small quantity of water in separate vessels. The former substance dissolves readily in cold water, but the latter may need the addition of warm water to make it easily soluble. The two solutions are then poured together and a milky white precipitate is at once formed, giving the mixture the appearance of a jar or bucket of milk rather than a deadly poison.*

The sprayings for the first and second broods of the leaf-folder were made at the Mount Arbor nurseries at Shenandoah. For the third brood the spraying was done at the Watrous nursery at Des Moines.

SPRAYING FOR THE FIRST BROOD. FIRST SPRAYING.

On April 25 and 27, 1908, 3-year-old apple stock at the Mount Arbor nursery, which was at this time badly infested with the leaf-folder, was sprayed with the home-made arsenate of lead. The larvae were then very small. In the light of succeeding experiments, however, it seems that the spraying should have been done at least a week earlier. The spraying apparatus used in the nursery consisted of a barrel pump mounted on a high-wheeled cart, built so as to straddle two rows of

*Laboratory experiments by Prof. Summers indicate that when concentrated solutions of the two materials are mixed the particles of the insoluble arsenate of lead are much larger than when the original solutions are much diluted. These larger particles settle more quickly than the fine particles resulting from the mixing of the dilute solutions. In view of these facts it would, no doubt, be best to add the solutions separately to the required amount of water, either directly into the spray tank, or to the water before placing it in the tank.

nursery stock. A single nozzle was used to a row and three or four rows could be sprayed at a time. In order to make a comparison, certain rows of trees were left unsprayed to serve as check rows. The following diagram shows the arrangement of sprayed and check rows in this first spraying. The rows in this block of trees were about 100 rods long.

SPRAYING FOR THE FIRST BROOD - EARLY SPRAYING

12Rows Check	12 Rows 6-18-50 Sprayed April 27, 1908	12 Rows 8-50 Sprayed April 25, 1908	12Rows Check	24 Rows 8-24-50 Sprayed April 25, 1908	12Rows Check	24 Rows 4-12-50 Sprayed April 25, 1908	100 Rods

The week following this early spraying was one of continued cold weather, which in itself had a decided effect in reducing the number of leaf-folders. This fact was shown by the relatively large percentage of dead larvae in rows which were not sprayed. Counts of the number of dead and living larvae were made on May 2. One hundred larvae were counted in each block of sprayed or check trees, with the exception of the 6-18-50 block, in which 200 were counted. The percentages of dead larvae are given in the following table:

PERCENTAGES OF DEAD LEAF-FOLDERS

Counted May 2. 1908

12 Rows Check No Count	24 Rows 6-18-50 46% Dead	12 Rows Check 37% Dead	24 Rows 8-24-50 56% Dead	12 Rows Check 26% Dead	24 Rows 4-12-50 46% Dead	100 Rods

On April 30 and May 1 3-year-old apple stock was sprayed with Paris green at the rate of one pound to 150 gallons of water. No definite counts were made on this lot of trees on account of the writer having to leave shortly after this spraying. Up to that time no very effective results were noticed, judging simply from general observations.

SPRAYING FOR FIRST BROOD—SECOND SPRAYING.

The results from the early spraying, while they showed that a benefit was secured by the use of the arsenate of lead, by no means came up to the expectations, and another spraying was planned for this same brood of leaf-folders. Consequently on May 11 and 12 other sprayings were made on the same block of apple stock which was sprayed before. In this spraying Bordeaux mixture was used with the arsenate, added as a fungicide. Since the Bordeaux mixture would have no effect on the leaf-folder it is disregarded in the tables. By the time

of the second spraying the larvae had begun to work on the upper portions of the trees. When the first spraying was made most of the larvae were feeding on leaves down near the base of the trees, on the snags. The accompanying diagram shows the different blocks of trees sprayed at this time:

SPRAYING FOR THE FIRST BROOD - SECOND SPRAYING

24 Rows 6-18-50 Sprayed May 12, 1908	12 Rows Check	24 Rows 8-24-50 Sprayed May 12, 1908	12 Rows Check	24 Rows 4-12-50 Sprayed May 11, 1908	100 Rods

An attempt was made to compare the number of dead and living larvae after this second spraying, but this comparison was unsuccessful, on account of the inability to find many dead larvae. Then another method of comparison was tried, an attempt to arrive at an average number of leaf-folders per tree, which would show a contrast between the sprayed and unsprayed trees.

In the blocks of sprayed and check trees the total number of live larvae on each one of 50 trees was counted. Dead larvae and very small larvae were not taken into account. Some of the larvae had by this time already pupated, but the pupae were counted as live larvae. The table, then, represents only the living larvae which were not killed by the spraying of May 11 and 12. If these counts showed a decidedly less average number of leaf-folders per tree on sprayed trees, for a certain number of trees, the inference would be that the spraying was of decided benefit. The averages, however, do not show this to be the case. Both the counts and averages are given herewith. The counts were taken on May 18 and 19.

SPRAYING FOR THE FIRST BROOD - SECOND SPRAYING

	4-12-50	Check	8-24-50	Check	6-18 50
Total number of living larvae on 50 trees.	126	273	167	189	199
Range per tree.	0-7	0-19	0-11	1-12	0-10
Average number of living larvae per tree.	2.52	5.46	3.34	3.78	3 98

As will be readily noticed the difference between the sprayed and unsprayed rows does not show that a benefit was obtained by this spraying. If anything is shown by the table, it is that a late spraying, made when the larvae are nearly mature, was really of no practical value. It will be noticed that there is a striking difference between the average of the 4-12-50 block and the check block next to it. This can probably be accounted for by the fact that most of the rows in the 4-12-

50 block were Northwestern Greening trees, a variety little affected by the leaf-folders. The small average in this block is due rather to a difference in variety than to the efficiency of the spray at that time.

SPRAYING FOR THE SECOND BROOD.

Since the early spraying for the first brood of the leaf-folders did not appear to be as effective as was anticipated, an application for the second brood was planned so as to have the poison on the foliage while the insects were still in the egg stage. Insectary and field records showed that the proper time for this application would be early in June. Accordingly on June 6, rows of 3-year-old apple trees in the same block as sprayed before were sprayed with Paris green and arsenate of lead. The rows sprayed, materials used, and the different strengths, are given in the following table:

SPRAYING FOR THE SECOND BROOD

Sprayed June 6, 1908

18 Rows Arsenate of lead 8-24-50	4 Rows Chec	18 Rows Arsenate of lead 6-18-50	4 Rows Check	20 Rows Arsenate of lead 4-12-50 (Resprayed by mistake)	4 Rows Check	8 Rows Paris Green 1-100

This spraying was done on June 6. On the 7th there came a downpour of rain and another heavy storm the night of the 12th. Nearly every day for more than a week after the spraying there was more or less rain. Owing to a misunderstanding on the part of the nursery people the rows sprayed with the single strength arsenate of lead were sprayed again the following week with a prepared brand of arsenate of lead. Only these 20 rows were resprayed at this time.

On June 15 a comparison was made between the different sprayed rows. In spite of the heavy rainfall the spray was still evident on the leaves, although it was badly washed from the rows sprayed June 6 with the 1½ and double strengths of the arsenate. The spray was still evident on the 20 rows which were resprayed, but on the rows treated with the Paris green only slight traces of the spray were found. Some burning of the foliage was apparent on the 8 rows sprayed with the 1-100 strength of Paris green.

In the comparison made June 15 between the sprayed and unsprayed rows young living larvae were found only in the unsprayed rows. No definite counts were possible, since the young larvae were killed soon after they hatched from the egg, and no traces of them were left. Judging, however, from the

general appearance of the stock and the number of larvae on the sprayed and unsprayed trees, the spraying was a success. No doubt some eggs which were delayed in hatching gave larvae which escaped this spraying. Two sprayings about ten days apart would be advisable where the larvae are exceptionally numerous.

SPRAYING FOR THE THIRD BROOD.

On July 20 a letter from Capt. C. L. Watrous of Des Moines stated that the leaf-folder had appeared on apple stock in his nursery. This occurrence gave an excellent opportunity for a repetition of the early spraying for the leaf-folder, applied at a time when the eggs were still unhatched. Accordingly on July 30 a block of apple grafts at the Watrous nursery was sprayed with the home-made arsenate of lead.

In this case only the single strength was used, and the application was made very thoroughly. Instead of the nozzles being attached rigidly to the spray cart, as they were in the Shenandoah work, they were operated by two men who walked behind the cart, each man with a nozzle in either hand. In this way the application was made much more thoroughly than when the nozzles were attached to a cross bar on the spray cart. Four rows were sprayed at a time with this arrangement. Near the middle of the sprayed block 8 rows were left unsprayed as check rows.

At this time there were still old larvae of the second brood in the leaves, as well as many pupae. Numerous empty pupa cases showed that the moths were emerging rapidly, so that the spraying was well timed.

The block was examined again on August 12 to determine the effect of the spray. On the sprayed rows at this time the leaf-folders were comparatively rare. A young larva was found in these rows occasionally, and also a chance specimen of an older larva of the second brood. On the 8 rows which were not sprayed the young larvae were very common, so that the difference between the sprayed and unsprayed rows was marked. The young folders at this time were in the terminal leaves of the grafts, folding the young tender leaves. As far as foliage was concerned the stock was in excellent condition. At a later visit on October 3 the stock was still in very good shape and not many of the folders were found. In the middle of the block, which was not sprayed, they were more numerous. Since the larvae did not all emerge at the same time it is probable that a part of the brood hatched out too late to be affected by the spray. A second spraying ten days after the first would probably have cleared the block of folders.

CONCLUSIONS.

From the work of the season it is very evident that, to be effective, any spraying for the lesser apple leaf-folder must be done when the larvae are very small, or before they are hatched from the egg. The early spraying for the first brood was only partially effective, presumably because the larvae had even then grown large enough to fold entire leaves over, and thus protect themselves from the poison. In the second spraying for the first brood no evident benefit was obtained, so far as could be determined.

The early spraying for the second brood, made at Shenandoah, and that for the third brood, made at Des Moines, were both effective in checking the leaf-folders. Both of these sprayings were made when the eggs were still unhatched, and the moths flying. In either case, on account of all the larvae not coming out at the same time, a second spraying ten days or two weeks later would have caught the late emerging larvae.

Where very thoroughly applied, as it was at Des Moines, the single strength home-made arsenate of lead is effective. However, if the nozzles are attached to a horizontal bar on the cart the spray will not be so well applied as it would if done by hand. In this case the next stronger mixture had better be used, the 1½ strength, or the 6-18-50 formula. In the Shenandoah sprayings this strength seemed to be as effective as the double strength, when applied at the proper time, and it is the strength considered by the writer to be the best one to use against the leaf-folder.

Paris green would probably be efficient if applied very early, that is, at the same time as advised for the arsenate of lead. With this insecticide there is likely to be more or less trouble in burning the leaves, a fault which the arsenate of lead does not have. However, if applied early enough, there seems to be no reason why the Paris green will not keep the leaf-folder in check. One-third of a pound of the Paris green to 50 gallons of water should be sufficient. When not used with the Bordeaux mixture about a pound of lime should be used with the Paris green to prevent burning of the foliage.

The prepared arsenate of lead may be used instead of the home-made material, if one does not care to mix the chemicals himself. The prepared material comes in a paste form which is placed directly into the barrel or spray tank. However, it will not remain in suspension quite as well as the fresh home-made material. The different brands of the prepared material vary considerably in their composition, so that it is difficult to decide just how much arsenate of lead should be used to a definite quantity of water. Generally, if the prepared material

is used, from 2 to 3 pounds to 50 gallons of water should be sufficient to control the leaf-folder.

PROPER DATES FOR SPRAYING.

Since there are three broods of leaf-folders during the year there will be three times during the season when one should spray. For the first brood the early spraying should come immediately after the leaves are out on the trees. The first spraying at Shenandoah was on April 25, and even this should have been about a week earlier to have obtained the best results. In an average season about April 20 would be the proper time to spray for the first brood. Farther north in the state this date should be a few days later.

For the second brood, the first week in June; and for the third brood, the first week in August; are the proper times for the early spraying, according to the experimental work of the past season. If the leaf-folders are exceptionally common these sprayings may be repeated ten days later in each case. These dates given are figured with the idea of having the poison on the leaves when the larvae are very young, or are still in the egg stage. It is always better to spray early than late. It is understood, of course, that the proper times for spraying will vary with the season.

COST OF SPRAYING.

In 50-pound lots, arsenate of soda and acetate of lead can be bought for as low as 15 cents a pound. At this rate 50 gallons of the different strengths of the home-made arsenate of lead would cost as follows: Single strength, 15 cents; 1½ strength, 22½ cents; double strength, 30 cents. The cost of the materials for spraying is not at all high, it is the labor which is the most expensive factor in nearly all spraying operations.

A reliable brand of the prepared arsenate of lead costs from 18 to 25 cents a pound, although some brands are offered for as low as 12½ cents a pound. Of the prepared brands 2 to 3 pounds of paste should be used to 50 gallons of water, making the cost of the spray from 40 to 60 cents for 50 gal. Thus the prepared material is decidedly more expensive than the home-made arsenate.

Paris green costs about 35 cents a pound, and if used in spraying for the leaf-folder, 1-3 to ½ pound would be necessary to each 50 gallons of water. Thus the cost per 50 gallons would be from 12 to 18 cents; somewhat cheaper than the home-made arsenate of lead.

Taking all things into consideration, however, the home-made arsenate of lead is recommended as the most effective

spraying material to use against the leaf-folder. It is somewhat more expensive than Paris green, but cheaper than the prepared brands of the arsenate. Both the home-made and the prepared arsenate of lead are better than the Paris green in that they are insoluble in water, thus there is no danger of burning foliage; that they are more adhesive to the leaves; and that they remain in suspension in the water better, and do not settle easily to the bottom of the barrel or spray tank.

The home-made arsenate has several advantages over the prepared article in that it is cheaper, can be made fresh, and when freshly made will remain better in suspension in the water. Then, too, the prepared brands come in a paste form, which soon dries out if not used, thus making more actual arsenate to any given weight, since the water is taken out. The dried arsenate is difficult to dissolve again when the time comes to spray. On the other hand the materials for making the home-made arsenate of lead do not necessarily need to be dissolved until just before using. Both the sugar of lead and arsenate of soda are easily soluble and the arsenate of lead is quickly made by simply pouring the two solutions together in the required amounts.

Spraying with one Friend nozzle to a row of nursery stock the cost of the material, figuring on the basis of 15 cents a pound for the two chemicals, was 8.8 cents per acre. Four or five barrels of solution could be put on in one day of ten hours and cover 10 to 12 acres of nursery stock. At Shenandoah the spray cart was hauled by a single mule, with one man to pump and drive at the same time.

STOCK SOLUTIONS FOR HOME-MADE PRODUCT.

The arsenate of soda and acetate of lead can be dissolved separately in kegs if desired, and mixed as they are needed. When any spraying operations are carried on to a very large extent this method of having the concentrated solutions dissolved in quantities will be found very convenient. The following method is suggested for use with the 1½ strength of the arsenate:

Dissolve in one vessel or keg 3 pounds of arsenate of soda in 4 gallons of water. In another dissolve 9 pounds of sugar of lead in 4 gallons of water. When ready to spray take two quarts of each solution and pour both into 50 gallons of water. The above amounts of the concentrated solutions are sufficient to make 400 gallons of spray of the 1½ strength.

The necessity for careful work in all spraying operations can not be emphasized too strongly. The poison must strike the leaves in order to do its work. Nozzles should always be clear and kept as near over the nursery row as possible. A

careful spraying will easily pay for itself in the saving of nursery stock, but a careless spraying is only a useless waste of time and materials.

PAST INJURY, DISTRIBUTION, AND FOOD PLANTS.

The lesser apple leaf-folder is not a new insect in Iowa, for it has in previous years caused injury to nursery stock in the state. In 1893 the apple stock in nurseries in the vicinity of Des Moines was troubled with this leaf-folder, although since that time there has been no serious injury recorded.

Many years ago in Illinois this small leaf-folder was known as a pest of apple stock in nurseries. It first appeared numerous in 1863 and again in 1870 and 1871. In 1883 and 1884 the species attracted attention in nurseries in the same state and Dr. C. M. Weed wrote a very good account of it at that time.* Dr. Riley writes of this leaf-folder, the two forms of which he treats as different species, in his Fourth Missouri Report.** In 1895 and 1896 the leaf-folder became a serious pest in some of the Missouri nurseries and Prof. J. M. Stedman of the Missouri Experiment Station published an account of the insect at this time.***

In Ohio in 1897 the leaf-folder became very injurious in a block of plum stock in a nursery at Troy, that state. Webster, in recording this outbreak, said that "In this case the insect proved a veritable scourge, hardly a green leaf being left on some of the younger trees in the nursery row."†

In the eastern part of the United States, particularly in New Jersey, this insect is known as a serious enemy to the cranberry. The name "yellowhead cranberry worm" has been applied to it when referred to as working in cranberry bogs. Dr. J. B. Smith, writing in 1884, said that the insect "is abundant everywhere in New Jersey." ‡

From a study of the literature of this insect it is seen that, both in the cranberry bogs in the eastern states, and in the apple stock of the nurseries in the middle western states, this leaf-folder has become at various times both abundant and destructive.

While the lesser apple leaf-folder has been known, for the most part, in the middle western states, such as Illinois, Iowa, and Missouri, and in New Jersey, it is by no means confined to that territory. Robinson, with his original description

*Weed, C. M.-15th Rep. State Ent. Ill. 1889. p. 75.
**Riley, C. V.-Fourth Rep. Ins. Mo. 1872. p. 46.
***Stedman, J. M.—Mo. Agr. Exp. Sta. Bul. 36. 1896.
†Webster, F. M.—31st Ann. Rep. Ohio State Hort. Soc. for 1897. p. 70.
‡Smith, J. B.—U. S. Dept. Agr. Div. Ent. Bul. 4. 1884. p. 22.

made in 1869, gave Texas as the habitat of the species. Prof. C. H. Fernald records the species from Nevada, and it also occurs in Maine. Taken generally, the species is distributed over practically all the United States as far west as Nevada, and as far south as Texas. It is not known in Europe.

As has already been mentioned the principal food plants of this leaf-folder are apple and cranberry. Barrows and Pettit report the larvae feeding upon the pear in Michigan. Prof. C. H. Fernald mentions the wild rose as a food plant, on the authority of Mr. G. M. Dodge of Glencoe, Nebraska, from whom he received specimens of the fall brood of moths. Dr. J. B. Smith has found the larvae feeding on the high-bush whortleberry in New Jersey and he suggests that this plant was the native food of the leaf-folder before it was attracted to the cranberry bogs. Since the huckleberry and blueberry are botanically closely related to the cranberry, they are probably occasionally infested by the larvae. Plum stock in the vicinity of a block of apple grafts at Shenandoah was found infested by the second brood of the leaf-folder in July. Eggs and larvae were found on the leaves, and the adult moths were flying in the rows when examined July 22. It has already been reported on the plum in Ohio by F. M. Webster.

In the varieties of apple stock at Shenandoah some difference in susceptibility to attack by the folder was noticed. In a block of 3-year-old stock the Northwestern Greening trees were only slightly infested while rows of Dutchess and Wealthy trees adjoining them were very badly infested. In a letter from Mr. D. S. Lake, of the Shenandoah Nursery, occurs the following statement:

> We find that the leaf-roller works in all varieties, but does not have much effect on the Northwestern Greenings. Neither is it bad on any of the northern sorts. They seem to keep on growing, while the more tender sorts check up.

Dr. S. A. Forbes, in recording an outbreak in Illinois in 1883 and 1884, mentions the fact that the thick-leaved trees were relatively little affected.*

CLASSIFICATION.

SYNONOMY.

The synonomy of this leaf-folder is rather complicated, owing to the fact that it was described several times by different entomologists and treated as a number of distinct species. The original description was published in 1869 by Coleman T.

*Forbes, S. A.—Trans. Ill. State Hort. Soc. for 1884. p. 124.

Robinson, who gave the moth the name of *Tortrix minuta.** In the next year, 1870, Packard described the moth as *Tortrix vacciniivorana,* bred from cranberry feeding larvae.**

Next LeBaron described the same species from moths bred from apple feeding larvae and gave it the name of *Tortrix malivorana.****

Again in 1872 Dr. Riley bred the slate colored winter moths in Missouri, and, supposing it to be a new species heretofore undescribed, gave it the name of *Tortrix cinderella.*† In 1875 it was described by Zeller under a fifth name, *Teras variolana.* ‡ Regarding Zeller's species Mr. August Busck, under date of December 7, 1908, writes me as follows:

> Zeller's *Teras variolana* was described from American material—one unique male from Texas (Ball coll.), now in the Aggassiz Museum of Comparative Zoology in Cambridge.
>
> It is probably (possibly) correctly made a synonym of *minuta* Robinson by Prof. C. H. Fernald and the species is so far as I know not recorded from Europe.

A possible synonym is *oxycoccana* Packard, but Prof. Fernald retains that name as a quite distinct species from *minuta.* Some of the older references to *minuta* were published under the name of *oxycoccana,* owing to an error in determination. Even in the case that *oxycoccana* and *minuta* were the same species Robinson's name *minuta* would still hold, since his description was published in February, 1869, while that of Packard's was not published until April, 1869.

The synonomy as given in Dyar's List of the North American Lepidoptera (1902), of which the Tortricidae was prepared by Prof. C. H. Fernald, is as follows:

minuta Robinson.
malivorana LeBaron.
vaccinivorana Packard.
variolana Zeller.
a. cinderella Riley.

The first four names were given to the orange moth. The slate form may be designated by the name *Peronea minuta cinderella* Riley.

COMMON NAME.

Dr. LeBaron first gave this insect its common name of the "lesser apple leaf-folder." Since it has been generally accepted for the species as an apple feeding insect that name is here used. As a cranberry feeder it is better known as the

*Robinson, C. T.—Trans. Am. Ent. Soc. ii. 1869. p. 276.
**Packard, A. S.—Mass. Agr. Rep. 1870. p. 241.
***LeBaron, Wm.—First (Second) Rep. State Ent. Ill. 1871. p. 21.
†Riley, C. V.—Fourth Rep. Ins. Mo. 1872. p. 47.
‡Zeller, P. C.—Verh. zool-bot. Ges. Wien. xxv. 1875. p. 212.

"yellowhead cranberry worm" or less commonly, the "yellow cranberry worm." A darker variation of the larva was called the "red striped cranberry worm," but which proved to be the same species as the other. Riley, in describing his *Tortrix cinderella,* the slate form of the moth, termed the insect the "green apple-leaf-tyer."

LIFE HISTORY.

Following is a brief outline of the life history of this leaf-folder. The eggs are deposited on the apple trees in the nursery rows early in the spring, hatching out the young larvae which work on the unfolding leaves. These larvae mature about the middle of May, and a little later go into the pupa stage, from which the orange-colored moths emerge during the first part of June.

These moths deposit their eggs on the leaves of the apple trees, and the eggs hatch in about a week, so that the second brood of larvae appear on the nursery stock by the middle of June. This second brood matures by the latter part of July, and early in August the orange moths again appear. Eggs from these moths begin to hatch by August 10; the third and last brood of the season. This last brood may extend over a considerable length of time, especially if the preceding broods are irregular in their appearance.

By the first of October most of the third brood larvae will have pupated, and in about two weeks later the moths will have appeared, this time the slate colored moths instead of the orange moths of the two preceding broods. Instead of depositing eggs at once the slate forms of the moths live over until the next spring, hiding under dead leaves, and in similar places. These moths place their eggs on the trees very early in the next spring, and from these eggs hatch out the first brood of leaf-folders for the year.

BROODS.

As far as known there are always three broods of the leaf-folders in Iowa. Farther north there may be only two broods. In a paper by Dr. H. J. Franklin, read at the Baltimore meeting of the American Association of Economic Entomologists, the species is credited with but two broods in the cranberry bogs of Massachusetts.

This spring, 1908, the young larvae were found very numerous at Shenandoah as early as April 25. From the size of the larvae at this time it seems probable that they were already about a week old. The first appearance of the larvae this year, then, was probably about the 18th of April. On May 18, at

Shenandoah, the first pupae from this brood of larvae were found. From their color they had evidently entered that stage a few days before, probably about the 15th of May.

Larvae were collected at Shenandoah at different times during the year and sent to Ames. In this way the appearance of the different stages of the insect in the nursery would be anticipated in the insectary. The first moths appeared in the insectary on May 24, and during the last few days of May and the first few days of June they continued to emerge in large numbers.

At Shenandoah June 6 moths were found very common in the apple stock. Most of the pupae were gone at this time and only an occasional mature larva was found. The eggs deposited by these moths were numerous on the leaves but none appeared to have hatched, and no young larvae of the second brood were found. On June 15 at the same place only an occasional moth was seen flying in the nursery, and but few pupae were still among the leaves. The newly hatched larvae of the second brood were just beginning to feed on the under sides of the leaves.

On July 18 there was received in the insectary at Ames a package of leaf-folders sent from the Mount Arbor nurseries at Shenandoah. A very few of these had already pupated when they were received, showing that the second brood in the field was entering the pupa stage and that the larvae were disappearing from the trees. The first moth of the second brood appeared in the insectary on July 20. At Shenandoah two days later the moths were found commonly among the apple stock, although pupae and larvae were still numerous. Occasionally a half-grown larva was found, but these rarely. At Des Moines on July 30 many moths were noticed flying in the nursery rows. Pupae were also common at that time. August 12 at Des Moines the young larvae of the last brood were numerous. Only one specimen of the moth was seen at that time, although mature larvae belonging to the second brood were not uncommon.

Some of the late second brood larvae from Des Moines, which were retarded in their development, were brought to the insectary and placed in a breeding cage. This was done to determine, if possible, how late they would lag behind the rest of the brood. They pupated August 31 and September 3, but the pupae never gave the moths. In another breeding cage in the insectary larvae of the second brood were present as late as September 5. From these records it is evident that larvae of the second brood may be retarded so much in their development that they would pass as larvae of the third brood. It is an interesting point, and one which was not determined in the

season's work, as to whether retarded larvae of the second brood would not produce the slate form of the moth. Unfortunately all those second brood pupae which were late in their development died in the breeding cages before giving the adult moths.

At Des Moines on October 3 pupae were found very numerous and a very few mature larvae with them. No empty pupa cases were found at this time, so it is assumed that the moths had not yet begun to emerge. From pupae gathered at Des Moines October 3 the slate moths emerged in the insectary beginning October 6 and continuing until October 16.

THE EGG.

The egg of the leaf-folder is very flat and more or less oval in outline, .4 by .6 mm in measurement. The chorion or shell of the egg is translucent and eggs placed on leaves appear slightly greenish on this account. The exochorion is pitted with fine hexagonal depressions which cross the egg transversely. The yolk is pale, similar in outline to the whole egg.

Fig. 5. Egg of the Leaf-Folder. Much Enlarged

In the spring these eggs were found on the bark of the apple trees in badly infested nursery stock. They were first found in this position at Shenandoah on May 3. All of the eggs found at this time were on the trunks of young trees within six inches of the soil. No eggs were noticed on the leaves of the apple trees early in the spring, but a thorough search for them was not made, and it is possible that the eggs are also placed on the leaves by the hibernating moths.

According to Riley the eggs are laid singly on the under surface of the leaf near the midrib. Observations during the summer showed that the eggs for the second and third broods of larvae were placed singly on the leaves, on the upper as well as the under surfaces. This was found to be the case both in the insectary cages and in the nursery. While no exact counts were made it appears from numerous general ob-

servations that about the same number of eggs are placed on one side of the leaf as on the other. In the insectary more eggs were placed on the under side of the leaf. A very few eggs of the second brood were found on the twigs of a small tree in one of the insectary breeding cages. In the nursery stock eggs were found on the bark of the trees only in the case of the first brood. On the under sides of the leaves the eggs were found scattered over the surface, sometimes near the midrib or one of the larger veins, and sometimes remote from them.

OVIPOSITION.

On May 25 several moths, male and female, were confined in a large breeding cage in the insectary at Ames, and two days later the females were seen to deposit their eggs. The details of the oviposition are taken from the notes made by the writer at that time.

May 26.—10:30 p. m. Have been watching this cage tonight for oviposition, but saw nothing. On the glass are only male moths. Two moths are resting on leaves, one on the upper side, one on the lower side.

May 27.—9 a. m. One female is seen on the glass. See no eggs.

May 27.—8:35 p. m. When I first looked in the cage I found only males on the glass. On the under side of a leaf I saw a moth which was moving her body from side to side in a jerky fashion. When I turned to get a better look the moth had left and a single egg had been deposited. This was on the under side of a leaf, away from the midrib. After the egg was found there were only two females on the glass sides of the cage. Many eggs are found over the glass sides of the cage.

9:04 p. m. Saw a female deposit two eggs on the glass. They were deposited separately, about forty-five seconds elapsing in the meantime. After remaining in one position for nearly half an hour this moth suddenly started towards the top of the cage along the glass sides. The course was irregular, not in a direct line. Then she stopped, raised the abdomen upwards somewhat in the middle, and brushed the surface of the glass as if to smooth it. All this took several seconds. Then raising up the abdomen still more the egg was forced out by several rapid contractions. Then the moth gave the egg two or three quick slaps from side to side with the tip of the abdomen, and at once left it. Going on up the surface of the glass she deposited another egg within forty-five seconds after the first, with the same procedure as before. After depositing this second egg the moth flew to the other side of the cage, but I saw her deposit no more eggs.

In some later ovipositions the moths at once left the eggs, paying them no further attention after they were deposited. In one instance I found a female with an egg just as if it had been dropped from the moth; directly beneath the ovipositor. The moth remained by the egg for ten or fifteen seconds after I noticed it, but paid the egg no further attention whatever.

Usually eggs were found singly, although in one instance among those found on the bark of nursery trees early in the spring, three eggs were found together. On the leaves, both

in the insectary cages and in the nursery, they were deposited separately.

NUMBER OF EGGS DEPOSITED BY ONE FEMALE.

Moths of the second brood were placed in insectary cages, one male and one female in each cage, in order to determine the number of eggs deposited by a single female. Counts in four cages by Mr. Henry Ness and the writer showed the number of eggs deposited by one female to be as follows: 210, 60, 96, and 50. This was an average of 104 eggs to one female moth. The cages consisted of cylindrical glass jars covered with netting. In these jars were placed apple twigs set into small bottles containing water. A considerable number of eggs were placed on the sides of the glass jars by the moths. In a count made by Mr. Ness August 7, the distribution of the eggs over the cage is shown as follows:

Eggs on leaf No. 1	23
" " " " 2	7
" " " " 3	42
" " " " 4	5
" " " " 5	7
" " " " 6	12
" " bottle in cage	6
" " sides of cage	108
	210

Quoting further from the notes of Mr. Ness he says: "No eggs could be seen on the stems or on the younger leaves, which were more or less downy. Neither were there any on the lower sides of the leaves, but were on the smooth upper surfaces of the older leaves and on the glass jar in which the moths were confined."

From insectary records of the second brood the length of the egg stage was determined as seven days, with a slight variation towards a greater length of time. The records of the time spent in the egg were very regular, the first larvae appearing in each case on the eighth day after the eggs were deposited.

THE LARVA.

The young larva as it is hatched from the egg is similar in appearance to other newly hatched leaf rollers. The yellow body and the darker head are very noticeable when the larva has just hatched from the egg. In length they are about 1.5 mm.

The very young larva usually begins to feed on the under surface of the leaf along the midrib. Some few were noticed feeding on the upper surface. The larva spins a slight web close to the midrib, by means of which it is held near to the leaf,

and while in this situation eats away small portions of the epidermis. Not until the larva attains some size is it able to eat entirely through the leaf. Feeding along the midrib as it does, the larva will eat through the leaf at that place, and on sprayed trees, will strike the poison which collects along the midrib on the upper surface.

When it is able to fold leaves the larva selects a soft, tender leaf which seems suitable for its purpose. If the leaf is very small the larva may fold it entirely over; if larger it may fold only a small portion of the margin over. The sides of the folded leaves are sewed tightly down, thus forming an excellent protection, while the larva works within. As has already been mentioned several tender unfolding leaves are frequently tied together by one or more larvae. In such a situation small holes are commonly found in the tender leaves where the folder has been feeding. Occasionally when two separate leaves are in close proximity the two are sewed flatly together by a larva, which feeds in the space between the two.

Early in the spring on 3-year-old nursery stock the majority of the folders were found on the lower parts of the trees, or on the "snags." The young larvae from eggs placed on the trunks of the trees naturally took to what suitable food they first encountered, that on the lower portion of the tree. At Shenandoah on April 25 the most of the young leaf-folders were at work on the leaves of the "snags," but about two weeks later, on May 11, they were working more on the upper leaves, although even then there were many larvae on the "snags" at the base of the trees. The larvae of the second and third broods work generally over the trees, showing no preference to one portion over another.

No definite data was obtained on the number of molts and the length of the several larval stages. In the insectary on May 9 one larva was seen to cast its skin. Quoting from the notes of the writer the process may be described in the following words:

> "Cast skin was just halfway off when I first saw it, and the old integument still remained on the head. The larva was using the thoracic legs and wriggling the old skin off by successive contractions of the abdominal segments. When the skin was nearly off the old head integument was thrown off by a sharp blow, the larva knocking its head against the soil. During most of the process the abdomen was high above the rest of the body in the air."

This larva has the habit of sending off its excrement to some distance when it defecates. Trouvelot first observed this peculiar habit, and it was noticed in the insectary during the summer. It is probable, as Weed suggests, that the stiff brush above the anal opening of the larva enables it to throw off the excrement thus forcibly.

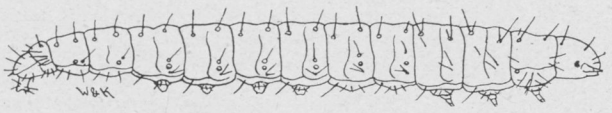


Fig. 6. The Larva. Enlarged

The description of the mature larva is given below.

Length 12 mm, greatest width 2.5 mm, width of head 1.5 mm. Body pale honey yellow, with a slight greenish tinge.

Head pale honey yellow; ocular area black; in some specimens a longitudinal black or brown mark caudo-laterad; mandibles brown, black at tips; labrum and labium pale, tipped with brown; antenna with proximal half pale, distal half brown. Clypeus long, acutely triangular, with two short setae in either lower corner, one candad to the other. Ocelli six; three in a direct line, a fourth cando-laterad of the first, fifth and sixth in line cando-laterad of the candad ocellus of the first three; ocular area black, the two caudad ocelli without pigmentation. Group guarded by three short setae below and three long seate in cephalo-lateral region; one long seta in caudo-lateral slightly cephalo-mesad of the ocular area; one long seta laterad, one long seta dorsad, about the middle of the head.

I. Cervical shield slightly wider than the head; width 1.7 mm; pale honey yellow; bearing twelve setae, six on either side of the meson, all near the margin of the shield; one short seta cephalad, near meson; two setae caudad, near meson, the laterad longer; two long seta in cephalo-lateral region; one long seta in caudo-lateral region. Laterad to cervical shield is a large tubercle, bearing three setae; directly laterad to this tubercle is a slightly smaller one, with two setae. "vii" on venter at base of leg, with three setae. II and III. i in the dorsal region, with two setae, laterad the longer; ii slightly advanced, setae same as i; iii single, caudad between ii and iv, near iv; iv single, laterad of ii; v single, directly laterad of iv and approximate to it; vi single, caudo-laterad of v; "vii" on venter, at base of leg, with three setae. IV. i cephalad, single, seta small; ii caudo-laterad of i, single, seta slightly larger than that of i; i and ii from dorsal aspect form a trapezoid, wider caudad; iii single, directly above spiracle, seta long; iv and v combined below spiracle and slightly cephalad, with two short, sub-equal setae; vi caudo-laterad of iv-v, single; vii cephalo-laterad of vi, with three short setae; viii in the ventral region, single, minute. V, VI, VII, VIII and IX the same. On X iii is cephalo-mesad of the spiracle. On XI ii is directly caudad of i, iii is cephaled to the spiracle. On XII i is on preceding segments; ii of either side are coalescent, forming a broad tubercle bearing two long setae; iv-v-vi coalescent, laterad to iii, with three long setae; vii laterad of iv-v-vi, with three short setae. Anal plate with three long setae on either side of the meson, the three forming a triangle with the apex caudad; one shorter seta caudad to the caudad long seta. Below tip of anal plate is a small comb-like structure bearing six short brownish spines. XIII. Two setae laterad below anal plate; three long setae caudad, on the anal legs; two shorter setae cephalo-mesad of the other three.

Thoracic legs pale, slightly brownish; tarsi brown to black; abdominal legs concolorous with the body.

THE PUPA.

The larva pupates in the leaf or bundle of leaves where it has been feeding. When the larva becomes mature it lines with threads the inside of the leaf or leaves within which it

Fig. 7. THE PUPA. ENLARGED

has been feeding before changing to the pupa. The pupa is described by Riley as follows.*

Length 0.25-0.30 inch. Brown; characterized by a peculiar rounded projection in front of the head; by a little pointed prominence at base of each antenna, and each side of the penultimate abdominal joint; and by terminating in a broad suppressed piece which produces two decurved hooks. Posterior rim of abdominal joints rasped dorsally, and a slight rasped dorsal ridge near the anterior edge of larger joints. Legs reaching only to end of wing-sheaths. The head-prominence varies in size and slightly in form.

In the different broods there was some variation in the length of time spent in the pupa stage. For the first brood the time varied from eight to fourteen days, with an average of 12.8 days. For the second brood the variation was from six to ten days with an average of 7.8 days. No very accurate data was obtained for the third brood pupae. From a lot of pupae gathered October 3 the moths began to emerge on October 6, continuing to October 16. If the moth which emerged last had just changed to the pupa stage when placed in the cage, the length of the stage would have been twelve days. It seems probable that the length of time spent by the third brood in the pupa is about the same as that of the first brood.

*Riley, C. V.—Fourth Rep. Ins. Mo. 1872. p. 47.

THE MOTH.

Prof. Fernald's description of the orange moth is given below. It is taken from Weed's article on the lesser apple leaf-folder.*

Orange form.—Expanse of wings, from 14 to 20 mm.

Head, palpi, thorax and fore wings above, orange-yellow. The fore wings are sprinkled with lead colored scales which are arranged somewhat in numerous cross lines. The fringes are somewhat lighter in color. The upper side of the hind wings and abdomen are pale fuscous and silky. The fringes and anal tuft are lighter. The under side of the wings and body, as well as the middle and hind legs, are pale yellowish white. The fore-legs are orange-yellow in front and pale yellowish-white behind.

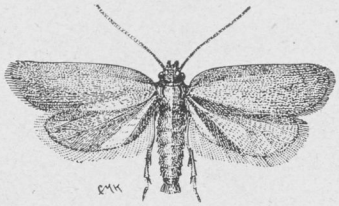


Fig. 8. ORANGE FORM OF THE MOTH. ENLARGED

During early June and again in late July and early August these orange moths are noticeable flying in rows of nursery stock. Their appearance in any numbers should be a warning to the nurseryman that then is the time to spray, rather than later, when the folders have hidden themselves securely away in the leaves.

In the insectary cages the orange moths lived from six to fourteen days after emerging from the pupa; an average of a little more than ten days. Eggs were usually deposited on the second or third night after the moths were placed in the cages.

Following is given the description of the slate colored form. This is also from Weed's article, and was written for that article by Prof. C. H. Fernald.

Gray form.—Expanse of wings, the same as the orange form.

Head, palpi, thorax and fore wings above, ashy gray with more or less chestnut-red scales mingled. In some specimens the red predominates; in others the gray; but they intergrade perfectly, so that no separation can be made. Occasionally a specimen will be found with darker scales arranged in cross lines like those of the orange form. A thoracic tuft with a chestnut colored tip is occasionally found. The fringes of the fore wings are ashy gray, sometimes stained with reddish. The upper side of the hind wings and abdomen are pale fuscous and silky. The fringes and anal tuft are lighter. The under side of the wings is pale yellowish fuscous, the hinder ones being a little

*Weed, C. M.—15 Rep. State Ent. Ill. 1889. p. 83.

lighter, and with a few brownish sprinkles along the costa and outer margin in some examples. The legs and under side of the body are somewhat darker than the wings.

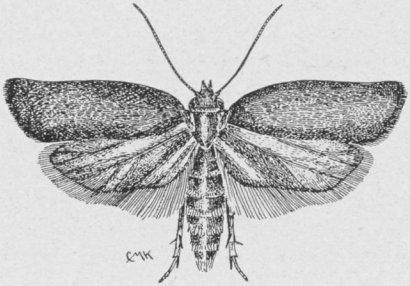


Fig. 9. Slate Form of the Moth. Enlarged

According to Dr. J. B. Smith the moths pass the winter in such places as outhouses, rubbish heaps, etc., until the following spring.

Among the orange forms of the moths which emerged in insectary cages of first brood larvae there were a few specimens which approached the slate form in appearance. None of these, however, were so much like the slate forms that they could not be readily distinguished from the moths reared in the fall.

NATURAL ENEMIES.

The natural enemies of the leaf-folder play a most important part in regulating its abundance. Where any food plant of an insect is cultivated on a large scale it gives to the insect an excessive amount of food, which in turn leads to an increase in numbers of the insect. So, too, with the increase in numbers of the insect there follows a corresponding increase in the natural enemies of that insect, since there is an abundance of food for those enemies. Among the most important of these natural enemies are the parasites, although birds and diseases are also important factors to be considered.

Barrows and Pettit note the observations of Prof. U. P. Hedrick, in Michigan, who saw blackbirds picking pupae of the leaf-folders from their shelters in the leaves.*

Chrysopa plorabunda Fitch. On July 22 and 23 several Chrysopa cocoons were found among apple leaves infested with the leaf-folder at Shenandoah. The adults emerged from a part of these cocoons and were determined by Dr. Banks, of the Bureau of Entomology at Washington as *Chrysopa plorabunda* Fitch. That the larvae of the *Chrysopa* are predaceous

*Barrows, W. B. and Pettit, R. H.—Mich. Agr. Exp. Sta .Bul. 160. p. 585.

on the leaf-folders seems very probable, although this was not directly observed.

From two of these cocoons were reared specimens of a brown Chalcid, determined by Girault as *Chrysopophagus compressicornis* Ashmead. This species was originally reared by Ashmead from *Chrysopa attenuata* Walker.

TACHINIDS. Two species of Tachinids were reared from leaf-folders sent from Shenandoah to Ames during the past summer. Prof. C. H. T. Townsend, of the Bureau of Entomology, has determined these as belonging to the genera Nemorilla and Bactromyia. They were not common at any time during the season. Another Tachinid, *Masicera eufitchiae* Towns, has been bred from *Peronea minuta* in Ohio by Webster.*

HYMENOPTEROUS PARASITES. As would be expected, the greater part of the parasites reared were hymenopterous. Mr. A. A. Girault of the University of Illinois kindly made the determinations of the Chalcid parasites. The remaining identifications were made by Mr. C. T. Brues of the Milwaukee Public Museum. Among the Chalcids it will be noticed that Mr. Girault has found three of the species to be new, for one of which, *Pediobioidea cyanea,* he erected a new genus. The technical descriptions of these species will be published elsewhere by Mr. Girault.

ICHNEUMONOIDEA. *Chorineaus carinatus* Cresson. This species, determined by Brues, is a parasite of the pupa of *Peronea minuta.* A single specimen was reared in the insectary on August 6 from a pupa which had entered that stage on July 20.

Clinocentrus americanus Weed. Of the primary parasites

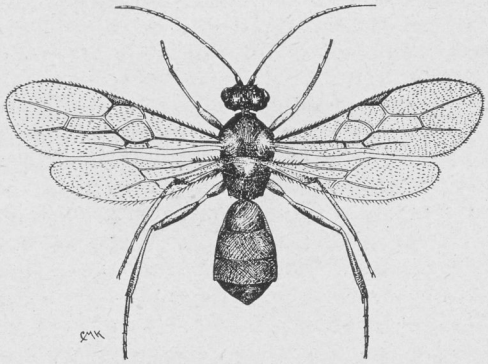


Fig. 10. *Clinocentrus americanus* WEED. MUCH ENLARGED
A common parasite of the leaf-folder

*Webster, F. M.—Can. Ent. xxx. p. 19.

reared during the summer of 1908 this little brown Braconid was the most common species. They first appeared from the second brood of larvae during the latter part of July. Insectary records for this brood of parasites give the range of dates of emergence from July 20 to July 29. In the third brood of leaf-folders this species was decidedly rare, occurring in only one cage and that on October 5. This reduction in numbers was probably due to the excessive hyperparasitism, although the difference in localities may have had something to do with it. The parasitized larvae from the second brood were gathered at Shenandoah, while those of the third brood were taken at Des Moines. Many cocoons were found among the third brood of larvae, apparently the same as those from which *Clinocentrus americanus* emerged, but they gave Chalcids instead.

Fig. 11. Cocoon of *Clinocentrus americanus*. Much Enlarged

The cocoons from which this species was reared were found usually within the leaf folded by the host larva. Three or four cocoons were found together as a rule, with the remnants of the dead larva attached to them. They were cylindrical, the color varying from pale yellow to a dirty white, and the average measurement was 2.8 by 1.1 mm. The adult insect emerged from a hole in the side of the end of the cocoon as shown in the accompanying figure.

This parasite was reared commonly from cocoons gathered at Shenandoah in July but only rarely from those gathered at Des Moines in October. In this last lot from Des Moines the Chalcid parasites of the two species next taken up were by far the more common. *Clinocentrus americanus* is not a new enemy to the lesser apple leaf-folder. Weed's original description was made from specimens reared from *Peronea minuta* in Illinois.*

Chalcidoidea. *Arthrolytus aeneoviridis* Girault MS. The exact relations of this parasite are somewhat in doubt. It belongs to the Pteromalidae, a family which contains both

*Weed, C. M.—Bull. Ill. State Lab. Nat. Hist. iii. 1890. p. 43. (description)

primary and secondary parasites. In the insectary rearings it usually occurred with the preceding species and issued from cocoons similar to those of *Clinocentrus americanus;* but this was not always the case. *Pediobioidea cyanea* also usually occurred in cages where the species in question was found. Where the three species, *Arthrolytus aenoviridis, Pediobioidea cyanea* and *Clinocentrus americanus* appeared in one cage, *Clinocentrus* appeared first, followed by *Arthrolytus* and the specimens of *Pediobioidea* issued last of all. Such was the case without a single exception. This would seem to indicate the hyperparasitism of the two latter species, with a possibility of *Arthrolytus* being a primary.

This species occurred in insectary cages from July 27 to August 2, from the second brood of larvae collected at Shenandoah; and from October 5 to November 12, from the third brood of larvae collected at Des Moines. These last rearings were from vials kept in a heated room in the late fall and are probably parasites which should not have emerged until the next spring.

Pediobioidea cyanea Girault MS. As has already been noted this species was reared usually in company with the two preceding parasites. All the data secured point to its being a secondary parasite with *Clinocentrus americanus* as a host and since it is a Eulophid, this is to be expected. There is a possibility of its being a parasite of *Arthrolytus,* since in one cage only those two species were found together and no *Clinocentrus* were reared from that lot of cocoons, although the cocoons were similar to those from which the last named species was reared in other cages. *Pediobioidea* then, might also be a tertiary parasite, with *Arthrolytus* as its intermediate host.

Where the three species were reared together, or only the two chalcids together, *Pediobioidea* without exception appeared last, after all the *Arthrolytus* had emerged. For the second brood of the leaf-folders the species in question appear-

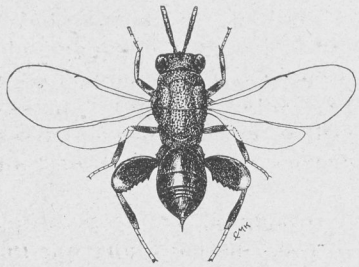


Fig 12. *Chalcis ovata* Say. A Parasite of the Leaf-folder Pupae. ENLARGED

ed from July 26 to August 3; for the third brood from November 17 to December 8. The last rearings were from a vial kept in a warm room and are probably individuals which should not have emerged until the following spring. The species was reared from material collected both at Des Moines and at Shenandoah.

Chalcis ovata Say. Late in the fall several specimens of this species were reared from *Peronea* pupae in one of the insectary

Fig. 13. LEAF-FOLDER PUPA FROM WHICH *Chalcis ovata* HAS EMERGED ENLARGED

cages. It is a common parasite of lepidopterous pupae so that its parasitism of the lesser apple leaf-folder is not surprising. *Chalcis ovata* was reared only from one lot of pupae which were collected at Des Moines on October 3.

Astichus bimaculati pennis Girault MS. This is the third of Girault's new species out of the lot of parasites determined by him. It is a secondary parasite of the family Eulophidae but its immediate host is not known. The species is recognized from a single specimen which emerged in the insectary on July 24th. The cocoon from which it issued is decribed in the insectary notes as being cylindrical, white, and measuring 1.4 by 4.3 mm.

Eulophus spp. Two species belonging to this genus were returned by Mr. Girault as "not determinable." They were reared from material collected at Shenandoah.

Habrocytus sp. One species belonging to this genus of the Pteromalidae was reared on July 27th. The cocoon from which it emerged is described as "cylindrical, brownish, 1.8 by 5.5 mm," so that the species reared from it was doubtless a hyperparasite.

Other parasites. In addition to the above list several Microgasters were reared from the leaf-folder but these reached Mr. Brues in poor shape so that he could not determine them. Following is a list of other parasites of *Peronea minuta* which

have been reared elsewhere but which were not found in Iowa during the past year's work:

Limneria elegans Weed.
Limneria teratis Weed.
Pimpla minuta Weed.
Cremastus forbesi Weed.
Apanteles cacoecia Riley.
Macrocentrus delicatus Cresson.

RELATIVE ABUNDANCE OF PARASITES.

During the second brood of the leaf-folder the primary parasites, principally *Clinocentrus americanus,* were the most abundant. This abundance caused a considerable reduction in numbers of the third brood of larvae at Shenandoah, which did little damage this fall, while that brood did considerable damage in the fall of 1907. The abundance of hyperparasites in the second and third broods, however, would counteract the abundance of the primary parasites, if not reduce their number to a minimum. Indications, then, point to a minimum of leaf-folders for the first brood next spring, but by the time of the third brood, the leaf-folder will be approaching, or possibly will have by that time reached, its maximum again. All this is theoretical, but the abundance of hyperparasites in the fall of 1908 points, first to a decrease in numbers of leaf-folders, followed by an increase later on.

CONTROL OF LEAF-FOLDER BY PARASITES.

If the natural enemies of an insect were depended upon to control that insect they would, without a doubt, do so if only given time enough, and provided that the amount of accessible food remained stationary from year to year. Even under these conditions a number of years would probably be required for the natural enemies and the insects to balance each other, even approximately. Assuming an abundance of insects at the start, this would be followed in turn by an abundance of primary parasites and a scarcity of insects, the oscillations continuing until an approximate balance between the two was reached.

When more food is raised every year for that insect Nature will be unable to keep the insect under her control. If man must raise more crops, he will, whether he wishes to or not, raise more insects to eat up those crops. If he would not continually disturb the "balance of nature" he would not be so troubled, but that he must do in order to live. So man cannot wait until conditions balance themselves, but he must take some preventive measures in order to insure his crops.

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